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ALGORITHMS FOR COMPUTATIONAL FLUID DYNAMICS

1 September 1980 - May 31, 1981

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THIS RESEARCH HAS BEEN SPONSORED IN PART BY THE AIR FORCE OFFICE OF SCIENTIFIC RESEARCH (NAM), UNITED STATES AIR FORCE, UNDER GRANT AFOSR-80-0249.

Progress in research conducted under this grant (AFOSR-80-0249) was made in two directions:

1. The influence of boundary conditions on two-dimensional calculations. The theory due to Kreiss et al [1], [2], [3] allows relatively easy application to one-dimensional flow problems. Recently results were obtained by Gustafsson and Oliger [4], and Yee, Beam and Warming [5] on the investigation of the stability of one-dimensional implicit schemes under various extrapolating boundary conditions.

We undertook to extend these studies to the two-dimensional case. The main result was to show that the expressions for boundary conditions must be written in a direction normal to the relevant boundary, otherwise instability will occur (unless the scheme is strictly dissipative).

These results have appeared in NASA/ICASE report No. 81-29 and will be presented at the NASA-Ames Symposium on Numerical Boundary Condition Procedures, to be held October 19-20, 1981 at Moffett Field, California.

2. Steady state computations for gas dynamic problems are often calculated using Beam-Warming [6] type algorithms. It is well known that the "delta" formulation, used to avoid splitting errors due to the implicit approximate-factorization scheme, is stable in two dimensions but unstable in three dimensions.

We have managed to overcome this difficulty by constructing an algorithm that remains stable in three dimensions while achieving steady state free of splitting errors. Numerical confirmations were obtained in collaboration with Dr. Douglas Dwoyer of NASA Langley Research Center.

These results will constitute a forthcoming NASA/ICASE report and are being submitted for presentation at the 8th International Conference on Numerical Methods in Fluid Mechanics, to be held June 28-July 2, 1982 in Aachen, West Germany.

References

1. Kreiss, H.O.: Stability Theory for Difference Approximations of Mixed Initial Boundary Value Problems. I. Mathematics of Computations, Vol. 22, 1968, pp 703-714.

2. Kreiss, H.O.: Difference Approximations for Initial Boundary Value Problems. Proceedings of the Royal Society of London, series A, Vol. 323, 1971, pp 255-261.

3. Gustafsson, B., Kreiss, H.O. and Sundstrom, A.: Stability Theory of Difference Approximations for Mixed Initial Value Problems. II. Mathematics of Computations, Vol. 26, 1972, pp 649-686.

4. Gustafsson, B. and Oliger, J.: Stable Boundary Approximations for a Class of Time Discretizations of $U_t = AD_oU$. Report No. 87, Dept. of Computer Science, Upsala U., Sweden, Sept. 1980.

5. Yee, H.C., Beam, R.M. and Warming, R.F.: Stable Boundary Approximations for A Class of Implicit Schemes for the One-Dimensional Inviscid Equations of Gas Dynamics. Proceedings of the AIAA C.F.D. Conference, paper No. 81-1009, June 1981.

6. Beam, R.M. and Warming, R.F.: An Implicit Finite Difference Algorithm f for Hyperbolic Systems in Conservation Law Form. Journal of Computational Physics, Vol. 22, 1976, pp 87-110.